Probing our **changing coast**

Coastal management in the UK for floods and erosion now takes a 100-year perspective. Such long-term decisions need a rigorous evidence-base. **Judith Wolf** describes two new projects, including the world's first coastal simulator, that aim to help.

Of all the beaches along the coast of Norfolk, the golden sand at Sea Palling, 20 miles from Norwich, is one of the most stunning. The dunes are officially Areas of Outstanding Natural Beauty.

A series of nine artificial reefs, dotted just off the coast and built by the Environment Agency in the 1990s, encourage wildlife. Seals are now common. The reefs create a sheltered harbour for swimmers and jet skis, attracting more tourists to the region.

The Environment Agency's prime reason for building these reefs was not to attract tourists or seals, though both are welcome. The low-lying county of Norfolk is vulnerable to flooding. During the 1953 storm surge along England's east coast, the sea breached the seawall at Sea Palling, killing seven people.

I am working on two very different projects to try to work out what is likely to happen to this coast over the next hundred years. One of them involves studying what is happening at Sea Palling and how we can design better sea defences. The other is creating the world's first coastal simulator. We are starting with the North Sea coast, and this bit of it in particular.

More than a quarter of the world's population lives close to the coast. We know that climate change is causing global sea levels to rise. This is already affecting coastlines. There are still some big uncertainties about the size of the rise this century.

In the UK, many people living by the sea, particularly in low-lying areas such as Lincolnshire or north Norfolk or on soft cliffs prone to coastal erosion, worry about what will happen to their homes. This is not helped by media reports saying insurance companies will soon refuse to insure large numbers of properties.

There are other uncertainties such as: will the UK face more or less storms in the future? More storms may mean more and bigger waves crashing onto our shores, accelerating coastal erosion. Wave heights may increase due to changes in the wind patterns or solely due to increased water levels along the coast.

So, how can coastal managers plan for future coastal development?

The research community is making a significant contribution to try to understand what the future holds. This is what brought me, Pete Thorne and a small team from Proudman Oceanographic Laboratory (POL) to Sea Palling.

For three years we've been working with Shunqi Pan and his team at Plymouth University and Chris Vincent and Tony Dolphin, with others in the Coastal Processes Research Group, at the University of East Anglia (UEA) on the Engineering and Physical Sciences Research Council-funded LEACOAST2 project.

The artificial reef, or offshore breakwater as it is also called, protects the coast by creating a wide beach in front of the existing dunes and seawall.

The breakwater design was based on guidelines developed for a micro-tidal area (that is, an area where the tidal range is less than two metres), unlike the situation at Sea Palling and elsewhere in the UK. The first reefs, the northernmost four, break the surface at high tide. The five further south are submerged at high tide. The aim is to improve the guidelines for coastal engineers when they design similar systems in the future.

We wanted to understand the sediment budget – how the sediment changes over time – of this part of the coastal system, with its strong tidal currents and occasional storm waves. These kinds of conditions

Sea Palling in Norfolk showing the breakwaters built to protect the coastline.

Sea Palling, Norfolk, during the storm surge of 1953.
Eastern Daily Press

make the sediment very mobile. We need to know how much of the sediment is trapped by the breakwater system and how much bypasses it to continue feeding the beaches to the south.

With great dedication, come wind or weather, the team has surveyed and measured changes to the beach, the lagoon and the sea beyond.

Our challenge was to deploy a set of instruments to measure currents, waves, fine sand and silt particles suspended in the water and seabed ripples in the surf zone – within the breakwater system and to about 100 metres seaward of the breakwaters. We also deployed an X-band radar system (developed by Paul Bell at POL) to monitor the nearshore zone for almost the whole project period (over two years).

These data show us the changes in beach volume and seafloor shape continuously over the last two years in unprecedented detail. We can also see the resuspended sediment rapidly increase after a storm wave event and the evolution of seabed ripples driven by waves and currents.

This kind of detailed information, combined with the spatial view from the radar and video systems monitoring long-term changes, is unique. These data are being used to develop state-of-the-art models of currents, waves, sediment transport and changes in coastal geometry.

The Coastal Simulator

Our fieldwork in north Norfolk ties in with the Coastal Simulator – a major project from the Tyndall Centre for Climate Change Research.

Tyndall researchers are creating the world's first simulator to assess: how coastal changes will physically affect a region, how these changes will affect the ecology, and the social and economic impacts of flooding and erosion. They are using the North Sea as a test bed for the system, and the first area under the spotlight is north Norfolk.

Once it works for Norfolk, Tyndall can take it elsewhere in the UK and eventually apply it anywhere on the planet.

The Coastal Simulator is an ensemble of different models connected together to allow integrated assessment of the coast under a range of scenarios, including climate-change projections. It uses a set of models that span processes from global to local scales including: sea-level rise, tides, surges, waves, sediment transport, coastal shape, coastal flooding, risk, ecosystem change and socio-economic change.

We create simulations for a number of scenarios to deal with the uncertainties inherent in future coastal management and socio-economic change. These simulations also consider world economic management scenarios which allow us to estimate the amount of greenhouse gases in the atmosphere in the future and the likely influence this will have on the global climate.

For my part, I am modelling offshore waves over the whole north-west European continental shelf using winds from the Met Office Hadley Centre climate model. These waves then provide input to the nearshore modelling and cliff erosion model.

From our preliminary analysis, there appears to be relatively little predicted change in the wave climate of the southern North Sea, though in other areas the model forecasts significant changes in wave height with an increase to the south-west of the UK and a reduction to the north of Scotland, largely due to changes in storm tracks.

Shifting shores

Shoreline management planning in the UK for flood, erosion and spatial planning now takes a 100-year perspective. Such long-term management decisions need a rigorous evidence-base.

In north Norfolk around 1400 properties are within 100 metres of the clifftop and 20,000 properties are within the coastal flood plain, illustrating many current coastal management issues.

Instrument recovery at Sea Palling in 2007.

Tyndall has developed the Coastal Simulator system in close consultation with local authorities and others with a stake in this challenge.

Early successes have allowed the effects of different coastal management options to be predicted for both erosion and flood risks. The results indicate the economic benefits of allowing coastal erosion in some locations because of the knock-on reduction of flood risk for people and habitats further along the coast.

Such early results clearly illustrate the benefits of the large-scale simulator-approach for informing long-term management decisions.

These evidence-based systems are essential if society is to manage uncertainty in vulnerable communities and make decisions on what kind of changes we are willing to accept. ❖

MORE INFORMATION

Dr Judith Wolf is a physical oceanographer at the Proudman Oceanographic Laboratory.

The Coastal Simulator is led by Professor Robert Nicholls from Southampton University and researchers from the University of East Anglia, the Met Office Hadley Centre, the University of Manchester and others.